SunTrac Design Team

18 September, 2019 - Northern Arizona University

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Project Description

The origin and sponsor of this project is SunTrac USA, located in Tempe, AZ.

They have tasked our Capstone team to design and provide drawings of a brazing jig capable of securing copper pipes in place while they are braze welded together.

A Jig is an apparatus that holds work and guides the tools operating on it.

- 4, 6, and 8 foot lengths of pipe
- Moves and allows easy access to pipes

Suntrac USA, will make parts to our drawings and we assemble the finished product at the end.

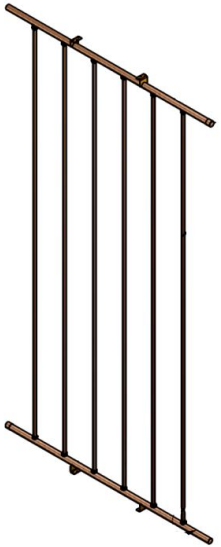

Figure 1: 8 Foot Copper Manifold

Background and Benchmarking

The copper manifolds are used in SunTrac's parabolic trough panels, and industrial sized AC and refrigeration units.

Copper is very thermaly conductive, and is often covered in black paint to absorb the sun's energy to serve as an evaporator/ heat exchanger

Their current jigs have fundamental problems.

- Braze welding with conductive copper heats up contact points on the jig
- Unbalanced axis of rotation
- Secured with jury- rigged components

Background and Benchmarking Cont.

Heat Spreads to Contact Points

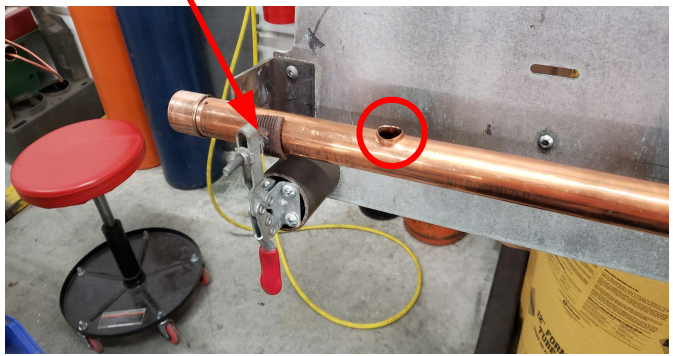

Figure 2: Copper Contact Points

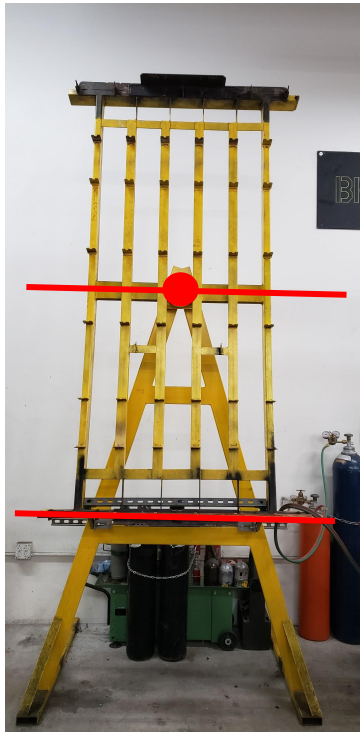

Figure 3: Axis of Rotation on 8 foot Jig

Locks Rotation

Figure 4: Jury- Rigged Part

Literature Review

Copper Sweating

Copper Development Association publication - ‘Soldering and Brazing Copper Tube and Fittings’

Copper Piping Design

Copper Development Association publication - ‘Copper Tube Handbook’

Machining Processes

Textbook - ‘Fundamentals of Modern Manufacturing’

Jig Material

Textbook - ‘Mechanics of Materials’

Pivot, Locking, and Clamping Mechanisms

Textbook - ‘Shigley's Mechanical Engineering Design’

Customer Needs

- Safe to Operate (5)
- Cost within budget (5)
- Can fit a 4’, 6’, and 8’ copper manifold (5)
- Standard or simple machined parts (4)
- Fit within a 5’x5’ square (3)
- Allow easy access to all copper joints (4)
- Jig can rotate and lock at various angles (3)
- Durable and Robust design (4)
- Reliable design (4)

Engineering Requirements

- Melting Temperature (degrees Celsius)
- Force to Rotate (Newtons)
- Cost (dollars)
- Versatile (number of compatible product variations)
- Standardized Parts (dollars)
- Footprint (meters^2)
- Degree of Rotation (Radians)
- Adaptable (Number of locking positions)
- Durable (Years before repair)
- Error (Difference in desired length)

House of Quality

Customer Requirement	Weight	Engineering Requirement	Melting Temperature (degrees Celsius)	Force to Rotate (Newtons)	Cost (dollars)	Versatile (number of compatible product variations)	Standardized Parts (dollars)	Footprint (meters^2)	Degree of Rotation (Radians)	Adaptable (Number of locking positions)	Durable (Years before repair)	Error (Difference in desired length) (in)
Desired Direction			^	v	v	^	v	v	^	^	^	v
1. Safe to Operate	5		9	9	9				1	1	3	
2. Cost within budget	5		1	1	9	3	9			1	9	9
3. Can fit a 4', 6', and 8' copper manifold	5				3	9		9	3			3
4. Machinable parts	4				9		9					
5. Fit within a 5'x5' square	3					1		9	3			
6. Allow easy access to all copper joints	4			1		3		1	9	9		
7. Jig can rotate and lock at various angles	3			3	1	9			9	9		3
8. Durable and Robust design	4		3	1	3	1	3				9	
9. Reliable design	4		3		3	1	1		1		3	9
Absolute Technical Importance (ATI)			74	67	168	110	97	76	96	73	108	105
Relative Technical Importance (RTI)			8	10	1	2	5	7	6	9	3	4
Target ER values			1400	13	1500	3	1500	2.32	2*pi	8	20	1/16"
Tolerances of Ers			300	3	500	0	500	0.5	0	2	5	1/32"

Figure 5: House of Quality

Schedule

	Start Date	End Date	Timeline	Authors	Status
SunTrac Team	9-2-2019	12-11-2019			
First Project Description	9-11-2019	9-15-2019		Kadeja	Complete
Background & Benchmarking	9-11-2019	9-15-2019		Nathan	Complete
Literature Review	9-11-2019	9-15-2019		Edwin	Complete
Customer and Engineering Requirements	9-11-2019	9-15-2019		Ethan	Complete
Schedule & Budget	9-11-2019	9-15-2019		Kadeja	Complete
Presentation 1: CNs/ERs and Background	9-11-2019	9-18-2019		All	Active
Peer Eval 1 due	9-18-2019	9-20-2019		All	Upcoming
Second Project Description	9-18-2019	10-6-2019		Kadeja	Upcoming
Concept Generation	9-18-2019	10-6-2019		Ethan	Upcoming
Concept Evaluation	9-18-2019	10-6-2019		Edwin	Upcoming
Budget Planning	9-18-2019	10-6-2019		Nathan	Upcoming

Figure 6: Piece of the Gantt Chart up to Presentation 2.

Budget

- The goal is to end up with a set of component drawings that can be given to a machine shop to have parts fabricated to assemble a jig.
- The drawings will be at our expense that Suntrac will own.
- The components built to our drawings will be at SunTrac’s expense.
- We will assemble the parts and modify drawings to achieve a workable brazing jig.
- We will try to reduce costs of machining by contacting and receiving quotes from the machine shop.

Thank You For Listening.

Any Questions?

References

[1] Copper Development Association Inc. (CDA) (2005). *Soldering and Brazing Copper Tube and Fittings*. [online] New York: CDA, pp.1 - 8. Available at: https://www.copper.org/publications/pub_list/pdf/soldering_brazing_ads.pdf [Accessed 12 Sep. 2019].

[2] Copper Development Association Inc. (CDA) (2019). *Copper Tube Handbook*. [online] New York: CDA, pp.1 - 96. Available at: https://www.copper.org/publications/pub_list/pdf/copper_tube_handbook.pdf [Accessed 12 Sep. 2019].

[3] Groover, M. (n.d.). *Fundamentals of Modern Manufacturing*. 5th ed. Hoboken: John Wiley & Sons, I

[4] Hibbeler, R. (2014). *Mechanics of Materials*. 9th ed. Pearson Prentice Hall.

[5] Budynas, R., Nisbett, J. and Shigley, J. (n.d.). *Shigley's Mechanical Engineering Design*. 9th ed. New York: McGraw-Hill,.

Appendix A

	Start Date	End Date	Timeline	Authors	Status
SunTrac Team	9-2-2019	12-11-2019			
First Project Description	9-11-2019	9-15-2019		Kadeja	Complete
Background & Benchmarking	9-11-2019	9-15-2019		Nathan	Active
Literature Review	9-11-2019	9-15-2019		Edwin	Active
Customer and Engineering Requirements	9-11-2019	9-15-2019		Ethan	Active
Schedule & Budget	9-11-2019	9-15-2019		Kadeja	Active
Presentation 1: CNs/ERs and Background	9-11-2019	9-18-2019		All	Active
Peer Eval 1 due	9-18-2019	9-20-2019		All	Upcoming
Second Project Description	9-18-2019	10-6-2019		Kadeja	Upcoming
Concept Generation	9-18-2019	10-6-2019		Ethan	Upcoming
Concept Evaluation	9-18-2019	10-6-2019		Edwin	Upcoming
Budget Planning	9-18-2019	10-6-2019		Nathan	Upcoming
Presentation 2: Concept Gen and Eval	9-18-2019	10-9-2019		All	Upcoming
Background PR	9-18-2019	10-13-2019		Kadeja	Upcoming
Requirements and Designs selected PR	9-18-2019	10-13-2019		Ethan	Upcoming
Design Space Research PR	9-18-2019	10-13-2019		Edwin	Upcoming
Concept Generation PR	9-18-2019	10-13-2019		Nathan	Upcoming
Preliminary Report due	9-18-2019	10-16-2019		All	Upcoming
Analyses Team Memo and Peer Eval 2	10-16-2019	10-20-2019		All	Upcoming
Website Check 1	10-16-2019	10-27-2019		All	Upcoming

Figure 7: Gantt Chart Part 1.

Appendix A

Third Project Description	10-20-2019	11-3-2019		Kadeja	Upcoming
Design Description	10-20-2019	11-3-2019		Ethan	Upcoming
Design Validation	10-20-2019	11-3-2019		Nathan	Upcoming
Design Requirements	10-20-2019	11-3-2019		Edwin	Upcoming
Schedule & Budget	10-20-2019	11-3-2019		Kadeja	Upcoming
Prototype	10-20-2019	11-3-2019		All	Upcoming
Presentation 3: Final Presentation	10-20-2019	11-6-2019		All	Upcoming
Background FR	10-20-2019	11-10-2019		Kadeja	Upcoming
Requirements FR	10-20-2019	11-10-2019		Ethan	Upcoming
Testing Procedures FR	10-20-2019	11-10-2019		Edwin	Upcoming
Risk Analysis and Mitigation FR	10-20-2019	11-10-2019		Nathan	Upcoming
Design selected FR	10-20-2019	11-10-2019		Kadeja	Upcoming
Final Report due	10-20-2019	11-13-2019		All	Upcoming
Peer Eval 3 due	11-13-2019	11-20-2019		All	Upcoming
Final BOM/CAD package due	11-13-2019	11-24-2019		All	Upcoming
Final prototype & Website Check 2	11-13-2019	12-1-2019		All	Upcoming
Analytical Reports & Peer Eval 4	11-27-2019	12-8-2019		All	Upcoming

Figure 8: Gantt Chart Part 2.